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✓ The BOD test is a laboratory method of measuring the quantity of dissolved oxygen required during stabilization of all or a portion of organic matter present in a waste by aerobic biochemical action. The test is performed by making suitable dilutions of the waste in appropriately prepared oxygen saturated water and then determining the dissolved oxygen used after a period of incubating, usually five (5) days. The authority for the BOD test is 10th edition "Standard Methods for the Examination of Water, Sewage and Industrial Wastes", page 260-266. The following is an interpretation of the accepted method with the pertinent points outlined in detail. The procedure outlined has been found to give reliable results.

Your attention is invited to the fact that the test was modified to some degree in 10th Edition Standard Methods (1955). This procedure supercedes those procedures based on previous editions of the Standard Methods. A detailed explanation of the test can be found in National Council Technical Bulletin No. 40.

Equipment Required

Incubator or Water Bath - This should be of adequate size to hold at least 50-100 BOD bottles. If possible, it should be large enough to store at least one 5-gallon jug of dilution water. The temperature should be maintained at 20°C (+ or -) 1°C.

BOD incubators are available from most laboratory equipment companies. Satisfactory incubators or water baths can be fabricated at the mill providing a source of cooling water is available that remains below 62°F the year around. Drawings of incubators or water baths suitable for the test are available upon request to any Council Office.

Relative humidity rooms that have a temperature controlled to the required limits may be used for incubation. If the average temperature is more or less than 20°C a suitable temperature correction of the computed BOD must be made using Table No. 2.

BOD Bottles - For convenience, commercially available 300 cc BOD bottles, serially numbered with individual numbered stoppers and water seals are recommended. Two dozen BOD bottles is the minimum number required.

Table 1

BOD RANGE CHARTS
(For 300 ml Bottles)

No. 1

For Samples with BOD of 450 ppm or Less

Sample (ml)	Dilution Factor	BOD Range (PPM)	Sample (ml)	Dilution Factor	BOD Range (PPM)
3	100	200-600	20	15	30-90
4	75	150-450	25	12	24-72
5	60	120-360	30	10	20-60
6	50	100-300	40	7.5	15-45
7	43	86-258	50	6	12-36
8	38	76-228	60	5	10-30
9	33	66-198	75	4	8-24
10	30	60-180	100	3	6-18
12	25	50-150	150	2	4-12
15	20	40-120	200	1.5	3-9
			300	1	2-6

No. 2

For Samples With BOD of 450 ppm or Greater
(Waste Sample is Diluted 1/10 - 1 volume waste to 9 volumes water)

Diluted Sample ml	Dilution Factor	BOD Range PPM
10	300	600-1800
20	150	300-900
30	100	200-600
40	75	150-450
50	60	120-360
60	50	100-300

The Dissolved Oxygen Determination

1. Remove stoppers from 8-10 BOD bottles.
2. Add 2 ml. manganous sulfate solution to each bottle (keeping pipette below surface of liquid).
3. Add 2 ml alkaline iodide solution (keeping pipette below surface of the liquid). Replace the stopper of each bottle as soon as this solution is added.
4. Rinse the bottles and mix by inverting 10 times.
5. Allow to stand until precipitate settles to $\frac{1}{2}$ point of bottle.
6. Mix again by inverting the bottles 10 times.
7. Let precipitate settle to the $\frac{1}{2}$ point again. To those bottles that do not show a completely white precipitate, add 2 ml of concentrated H_2SO_4 .
8. Rinse the bottles and mix by inverting until the floc disappears.
9. Titrate 200 ml of sample (or the calculated volume corrected for normality of the sodium thiosulfate -- see preparation of Reagents for determination of this volume) in a 250 ml beaker. Add the sodium thiosulfate (0.025N) stirring continuously until the solution reaches a pale straw color. Add a dash of starch and titrate dropwise until one drop destroys last trace of blue color.
10. Record the volume of thiosulfate used as PPM dissolved oxygen in the sample.
11. If excess sodium thiosulfate is added, the end point is passed, use the 100 ml of sample remaining. The ml of the thiosulfate used multiplied by 2 is the dissolved oxygen concentration in the sample.

Preparation of the Dilution Water

- ✓ 1. Aerate distilled water free of copper to about 8 ppm D.O., place a cotton plug in the neck and let stand for 2 or 3 days at 20° to 25°C. When ready to set up BOD's, draw off into another bottle slightly in excess the amount of water needed to perform the test. It is convenient to calibrate this bottle in liter increments.

To this bottle add each of the following solutions at the rate of 1 ml. per liter, or 3.8 ml. per gallon, or 12 ml per carboy.

- (a) Phosphate buffer.
- (b) calcium chloride.
- (c) magnesium sulphate
- (d) ferric chloride

The preparation of these solutions is covered later.

Preparation of the Dilution Water (cont)

2. Seed the dilution water in the second bottle with well settled domestic sewage that has been aged and acclimated as described below. Add sufficient seed to obtain a drop of about 0.5 ppm C.O. in the dilution water during the incubation period. Experience will dictate the amount of seeding material required. The amount added normally falls between 1 and 10 ml per liter of dilution water. Three ml/liter is a recommended dose if there is insufficient experience available to determine the dose.

To prepare the seed, collect domestic sewage that has not been chlorinated, add 10 ml of the waste per liter of sewage and let stand in an open wide mouth jar for 24-36 hours at 20°C. Do not use seed that is more than 48 hours old.

Dilution water to which phosphate buffer and seed have been added should be discarded after one day.

The quality of the dilution water and viability of seeding material are best checked by determining the BOD of standard solutions of glucose or glutamic acid. This procedure is outlined later.

Preparation of Reagents and Solutions

✓ (A) Nutrients for BOD Dilution Water.

1. Phosphate Buffer Solution - Dissolve 8.5 grams KH_2PO_4 , 21.75 grams K_2HPO_4 , 33.4 grams $\text{Na}_2\text{HPO}_4 \cdot 7\text{H}_2\text{O}$ and 1.7 grams NH_4Cl in about 500 ml of distilled water and dilute to 1 liter. The pH of this solution should be 7.2 without further adjustment.
2. Calcium Chloride Solution - Dissolve 27.5 grams CaCl_2 (anhydrous) in distilled water and dilute to one liter.
3. Magnesium Sulfate Solution - Dissolve 22.5 grams $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ in distilled water and dilute to one liter.
4. Ferric Chloride Solution - Dissolve 0.25 grams $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ in distilled water and dilute to one liter.

✓ (B) Reagents for the Dissolved Oxygen Test.

1. Manganous Sulfate Solution - Dissolve 480 grams $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$ (or 400 grams $\text{MnSO}_4 \cdot \text{H}_2\text{O}$) in distilled water, dilute to one liter. Filter out or settle out precipitate and retain the supernatant.

This is usually bought in solution already prepared as explained below.

- ✓ 2. Alkaline Iodide Solution - Dissolve 500 grams NaOH (or 700 gms. KOH) in 500 ml of distilled water.

Dissolve 150 gms of KI (or 135 grams NaI) in 150 ml distilled water.

Dissolve 10 gms sodium azide in 40 ml water.

After all mixtures have dissolved and cooled, mix and dilute to one liter.

This solution is stable for one month. The caustic and iodide solutions may be mixed, diluted to 950 ml and stored for long periods of time. As required dissolve 1 gram sodium azide in 5 ml of distilled water and add to 100 ml of the caustic-iodide solution.

- ✓ 3. Sulphuric Acid - Reagent Grade - SG 1.83-1.84.

- ✓ 4. Sodium Thiosulfate - N/10 Stock solution. Dissolve 24.82 grams $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ in 750 ml distilled water and dilute to one liter. This solution may be preserved with 5 ml chloroform or 1 gram NaOH.

Sodium Thiosulfate - N/40 (0.025N) solution. Dilute 1 volume of N/10 stock solution with 3 volumes of distilled water. Standardize this solution every 3 weeks by the following procedure.

- (a) Add about 5 grams KI crystals to each of three 300 ml Erlenmeyer flasks.
- (b) Add 150 ml of distilled water and dissolve the crystals.
- (c) Add 10 ml 1:10 H_2SO_4 (10 ml H_2SO_4 + 90 ml distilled water) to each flask.
- (d) Add exactly 25 ml of Standard Bi-Iodate Solution to each of the flasks with a burette or volumetric pipette.
- (e) Dilute to 200 ml and titrate with the thiosulfate solution. Add starch toward the end of the titration when a pale straw color is reached. Add thiosulfate dropwise until one drop just destroys all the blue color.

Example

Standardization of Thiosulfate.

ml Standard-Bi-Iodate	ml Thiosulfate Solution
25	25.4
25	25.4
25	25.7
	Ave 25.5

Normality of Thiosulfate = $\frac{25.0}{25.5}$ X 0.025
ml thiosulfate required

$$= \frac{25.0}{25.5} \times 0.025 = .0245 \text{ N}$$

Size of sample to be used in titration = $\frac{0.025}{.0245} \times 200 = 204 \text{ ml}$

6. Standard Bi-Iodate Solution - For stock solution, dissolve exactly 1.625 grams $\text{KIO}_3 \cdot \text{HIO}_3$ in 400 ml distilled water and dilute to 500 ml. This solution is N/10.

The N/40 (0.025 N) standard is prepared as needed by diluting 1 volume of the stock solution with 3 volumes of distilled water.

7. Starch Solution - Make a paste using 5 grams water soluble starch and a little distilled water. Pour this emulsion into 1 liter of boiling distilled water, allow to boil a few minutes, cool, settle and save the supernatant. Preserve with 1.25 grams salicyclic acid or a few drops of toluene.

Checking Quality of Dilution Water & Seed Viability

Prepare standard solutions each time used by dissolving 300 milligrams of C.P. glucose or C.P. glutamic acid in distilled water and diluting to one liter.

The glutamic acid solution should show a BOD of 217+ or -10 ppm. The glucose should show a BOD of 224+ or 11 ppm. An appreciable divergence from these results should raise question as to either the viability of the seed or quality of the distilled water.

Variations greater than + or - 22 ppm, more than 5% of the time indicate that the technique used is subject to improvement.

When using purchased distilled water it is well to determine the BOD of glucose or glutamic acid using the water from each jug of water purchased.

Dechlorination of Waste Samples

To a ~~200~~ ¹⁰⁰ ml sample add approximately 1 gram KI crystals. Dissolve the crystals. Adjust pH of sample to ~~3.0-4.0~~ ^{1.0}. Titrate with 0.025 N sodium thiosulfate until the solution is a pale yellow, add a dash of starch and titrate until one drop destroys the remaining blue color.

Add to a ~~200~~ ml sample of the waste the amount of thiosulfate determined above. Let the sample stand 10-20 minutes, then set up the BOD's using this sample.

Cleaning Glass Ware

BOD bottles should be cleaned after each use with dichromate cleaning solution and then thoroughly rinsed.

Prepare the cleaning solution by dissolving approximately 100 grams of potassium dichromate, or sodium dichromate in 375 ml distilled water and make up to one liter with concentrated H_2SO_4 . Add the acid to the water solution slowly with constant stirring.

The dilution water jugs, siphons, etc. should be cleaned occasionally with strong chlorine solutions to kill any residual algae growth.

Trouble Shooting the BOD Test

Since the BOD test is a bio-assay reliable results are dependent on the nature of the waste, the technique employed, and cleanliness of equipment.

On rare occasion, even after proper treatment of the sample, a sample may exhibit some toxicity. This is evidenced by successfullly higher BOD values as the dilution becomes greater.

Most paper mill wastes, if prepared as previously outlined, do not exhibit toxicity.

Sloppy measurements when adding waste to the bottles is a common source of error. Poorly mixed samples from which a representative sample cannot be obtained is another source of error. Over shooting the end point is a third source of error in technique. This can be avoided by dropwise titration toward the end of the titration.

Erratic BOD results can be caused by improperly cleaned equipment. Excessive drops in D.O. in the incubated blanks may be caused by the presence of algae.

If the precautions outlined herein are followed and trouble with the test is encountered, contact your Council Regional Engineer.

Pounds BOD per Ton

Month	Last Day of Account in Month	Total Production Tons	Total Dry Ton	BOD Began Primary Dry Wg.	BOD After Primary Dry Wg.	# BOD Ton
1-65	1-24	2,472				
2-65	2-28	3,033				
3-65	3-28	3,654				
4-65	5-2	4,522				
5-65	5-30	3,859				
6-65	6-27	3,442				
7-65	8-1	4,423	126.3	3692	2217	29.2
8-65	8-29	2,883	103.0	2870	1814	27.9
9-65	9-26	3,728	133.1	4507	3061	33.9
10-65	10-31	4,641	132.6	3797	2705	28.6
11-65	11-28	3,983	142.3	2604	1735	18.3
12-65	12-31	3,502	106.1	3229	2357	30.4
1-66	1-30	3,443	114.8	5374	4005	46.8

EVALUATION OF WASTE SOLIDS AND B.O.D.

1. Install a weir in No. 2 sewer to get an idea of flow, B.O.D. and total suspended solids going to the river.
2. If the results in the preceding are high then we should pipe the water from No. 2 sewer to the waste treatment plant. This will allow us to reduce solids in the water by 80% and B.O.D. by 30%.
3. If the efficiency of the waste treatment tank falls below 80% we should reduce the amount of fresh cooling water going to the treatment plant. At present we are operating the treatment tank at better than 80% efficiency.
4. We should reuse as much white water in the mill as practically possible. This includes consistency regulators in the beater rooms and on machines, wire showers on No. 2 and centricleaner dilution on No. 4.
5. The gate on No. 3 sewer should be modified so that water will not flow to the river when the gate is down. At present a considerable amount of water goes to the river even when the gate is closed.

6. We will check the B.O.D. of zinc hydrosulfite wash water. We are already checking the solids. From this information we can determine how serious a disposal problem the zinc hydro water will be.
7. When the waste treatment tank solids removal efficiency drops below 80% we can consider coagulating aids. Before this is done we should remove all possible fresh water going to the treatment tank.
8. A coagulating agent may help our B.O.D. but we will have to check on our specific wastes. Work is being done on this by Andre Carron in Kalamazoo.
9. We are going to check the B.O.D. of starch to see what the amount of B.O.D. could be on a dump of starch into the river. At present the drain from the starch room goes directly to the river.
10. As per last conversation with Andre Carron it was agreed that all possible steps should be taken to keep from going to secondary treatment of wastes. Not only would the initial cost be high but the operating cost is very high.

If we still have an excessive amount of B.O.D. after we make the preceding changes it is recommended that we go to spray irrigation. We would spray only that volume of water necessary to keep our loss to the river under the maximum lbs. of B.O.D. allowed. This would be the most economical way to handle the problem if we can not get the B.O.D. low enough by reusing white water.

NATIONAL COUNCIL FOR STREAM IMPROVEMENT
(OF THE PULP, PAPER AND PAPERBOARD INDUSTRIES)
INC.

271 MADISON AVENUE
NEW YORK 16, NEW YORK

February 10, 1964

TECHNICAL BULLETIN

Number 172

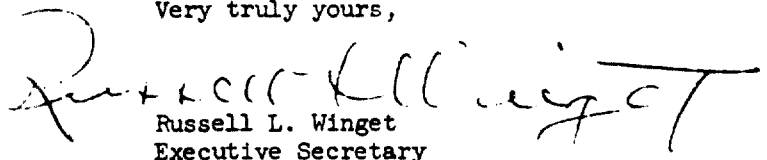
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THE APPLICATION OF STABILIZATION PONDS
IN THE PURIFICATION OF PULP AND PAPER MILL WASTES.

The most widely used method for reducing the BOD of pulp and paper mill effluents, is by the use of stabilization basins, wherein effluent is stored and allowed to oxidize by natural means. The National Council for Stream Improvement's Technical Bulletin No. 172, summarizes the development and present practice within the industry and describes the improvements being made and under investigation toward raising the efficiency of this process.

The recent trend toward oxygenation of stabilization basins by aerating them mechanically, has reduced the storage period required to less than 10% of that required for unaerated basins providing the same degree of purification. This practice, together with a number of inherent advantages pointed out in the attached bulletin, will undoubtedly increase its application by the industry.

Very truly yours,


Russell L. Winget
Executive Secretary

RLW:SC
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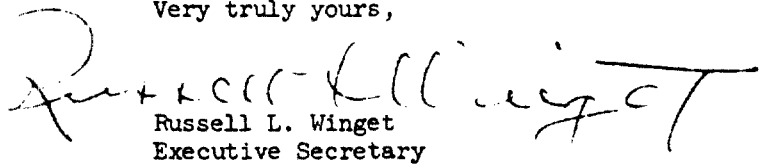
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THE APPLICATION OF STABILIZATION PONDS IN THE PURIFICATION OF PULP AND PAPER MILL WASTES

Harry W. Gehm

The use of stabilization basins for the reduction of BOD of pulp mill effluents is the most widely practiced form of secondary treatment employed by the pulping industry today. Twenty-three large kraft pulp mills employ this technique as do two large chip board mills. In addition, quite a number of small mills have stabilization basins. The reasons for the selection of this form of treatment are as follows:

1. **Geographical Location:**—Most mills employing stabilization basins are kraft pulp mills located in the south where exceptionally low receiving stream flows and high water temperatures are observed seasonally, hence effluents require secondary treatment. At many mills in the south, large areas of suitable land are available and the high ambient temperatures promote a high level of microbial activity in stabilization basins for the greater part of the year. North temperate climates provide suitable conditions in some cases, but their use in the northern climates is not feasible.

2. **Responsiveness of Effluent to Treatment:**—Effluent from modern kraft mills is of about the same strength as domestic wastewater in terms of BOD (150 to 300 mg/l), oxidizes at a similar rate and does not

contain substances inimical to the bacterial activity. Although nutrient addition is required for oxidizing this waste efficiently by the activated sludge process, their addition does not appear measurably stimulating to the oxidation rate.

3. **Reliability of the Process:**—Properly designed and managed stabilization basins are more reliable in terms of consistency of effluent quality than mechanical treatment systems since they are not subject to breakdowns and handle periodic overloads without upset. This is an important advantage in any stream pollution control process since months of successful operation can be destroyed by one day of failure.

4. **Flexibility:**—The degree of treatment is controllable within reasonable limits since it is proportional to the area and depth of the basin employed for a given discharge.

5. **Capital and Operating Cost:**—The capital and maintenance costs of stabilization basin treatment is generally a fraction of that of mechanical secondary treatment and the operating cost is considerably lower.

Treatment Discussed

Such treatment in the pulp and paper industry has been an outgrowth of the waste holding basin first employed by some kraft mills for protection of receiving waters. When these mills were built, the spent liquor recovery system was still rather primitive, as were some of the unit processes

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and equipment employed in it. System chemical losses were about five times higher than from the modern recovery plant, and frequently slugs of spent cooking liquor found their way to the sewer. In order to prevent direct discharge of the strong and caustic effluent produced by the old systems at low receiving stream flows regulating basins were constructed at many mills.

As improvements such as counter-current vacuum pulp washing, the long tube multiple-effect evaporator, continuous causticizing, and others were employed in recovery plants, losses decreased radically and upsets became infrequent. This progress was reflected in a decided change in effluent character. The waste lost its strong causticity and became relatively neutral and weak in strength as measured by other criteria. Pesch (1) reports a U. S. Public Health Service survey indicating nearly 70-percent decrease in pounds of BOD discharged per ton of product between 1935 and 1950 as a result of recovery plant improvements.

It was observed by Hodges (2), Davis (3), and others that an appreciable BOD reduction occurred in holding basins. This phenomenon was studied in the field and the laboratory by Carpenter and Porter (4) and by Moggio (5). They demonstrated that the oxidation observed on storage was due mainly to microbial decomposition and not to atmospheric oxidation of reducing substances present in the waste as some previously believed. Their investigations also revealed the necessity for removing fiber from the waste previous to storage. When deposited on the bottom of a basin, fiber liquefies rapidly adding very appreciably to the effluent BOD. Another difficulty is that gassification occurs, floating the fiber to the surface and preventing oxygen absorption from the atmosphere. The rate of fiber decomposition under these conditions has been reported by Lardieri (6).

As a result of these investigations, some mills soon built stabilization basins, and existing waste storage basins at others were adapted to this purpose. Crawford (7) as well as Bishop and Wilson (8) reported on results obtained at two such early installations. Units of this type provided a detention period for the effluent of from 15 to 30 days and reduced the 5-day oxygen demand between 50 and 70 percent during the warm months. No attempt was made to design them at a fixed depth since the natural topography determined their configuration. Rather, the site was generally selected on the basis of obtaining the greatest capacity in the smallest area. BOD loadings ranged from 0.6 to 1.2 lb/day/1,000 sq ft (0.07 to 0.14 g/day/sq m).

These stabilization basins are not strictly aerobic in activity but symbiotic with both aerobic and anaerobic microorganisms being active in the purification process. It has been established that oxygen is dissolved in water only at the liquid-air interface and is transferred to deeper portions of a quiescent body of water by diffusion downward of the thin layer of oxygen saturated water at the water-air interface (5)(9).

The importance of surface absorption of oxygen has been reported by Amberg (10). These data indicate that 40-percent BOD reduction occurred in 3 days at a depth of 6 in. (15.2 cm), 8 days at 2 ft (0.6 m), and 20 days at 6 ft (1.8 m). Amberg also investigated the effect of aeration at a four foot depth. Aeration for a period of 4 days produced a BOD reduction in the waste in excess of 90 percent, while an unaerated waste was reduced only 40 percent after 14 days' storage at the same depth. Of interest also in respect to oxygen transfer at the surface of a basin is the work of Riddick (11). Although his studies were not concerned with oxygenation, they illustrate the effectiveness of a low degree

TABLE I.—BOD Reduction by Flowage of Kraft Mill Effluents in Shallow Stream Beds
[Approx. 7 miles (11 km) flowage]

Mill No.	Treatment	Untreated Mill Eff. BOD (mg/l)	Final Eff. BOD (mg/l)	Reduction (%)
1	Flowage and Storage	Max.	293	83
		Min.	82	
		Avg.	147	
2	Flowage Only	Max.	133	65
		Min.	50	
		Avg.	97	
3	Flowage Only	Max.*	62	40
		Min.	24	
		Avg.	44	
4	Storage and Flowage	Max.	111	99
		Min.	97	
		Avg.	104	

* Effluent mixed with stream.

of aeration in promoting circulation, hence greater surface exposure and mixing in stored bodies of water. Berger (12) gives data on the BOD reduction observed on flowage of kraft mill effluents in shallow stream beds. These data, summarized in Table I, indicate that the oxygenation obtained by such flowage is very effective in promoting stabilization.

Because of these observations, considerable effort is being made to both improve effectiveness of existing basins as well as extend the usefulness of the process by reducing the storage time requirement improving reoxygenation. Recirculation and aeration also allow treatment of stronger wastes such as boardmill effluents which range generally from 300 to 600 mg/l BOD.

Operational Examples Given

One example employing both storage and flowage is the system employed at the Valdosta, Florida, mill of Owens-Illinois Glass Co. This installation, as reported by Webster (13), achieves a 90-percent BOD reduction

through passage through two large oxidation basins followed by flowage and further retention in three small ponds in series. A similar degree of effectiveness is attained by a series of shallow basins, having an average depth of 3 ft (0.9 m) and an area of 600 acres (243 hectare), at the Continental Can Co. mill in Augusta, Georgia, described by Heustis (14) (15). This is the first installation designed to provide shallow storage for the purpose of obtaining higher efficiency from the improved natural reoxygenation so obtained.

Recirculation and aeration in stabilization basins by means of low lift irrigation type pumps returning over riffles is employed to treat boxboard mill effluent at the Crown Zellerbach Corp. mill at Baltimore, Ohio. BOD reduction consistently exceeds 50 percent during the summer months with an average detention period in the two basins of 6 days. Turnover achieved by the recycle pumps is once a day. Because of the strength of the waste treated (500 to 600 mg/l) and the

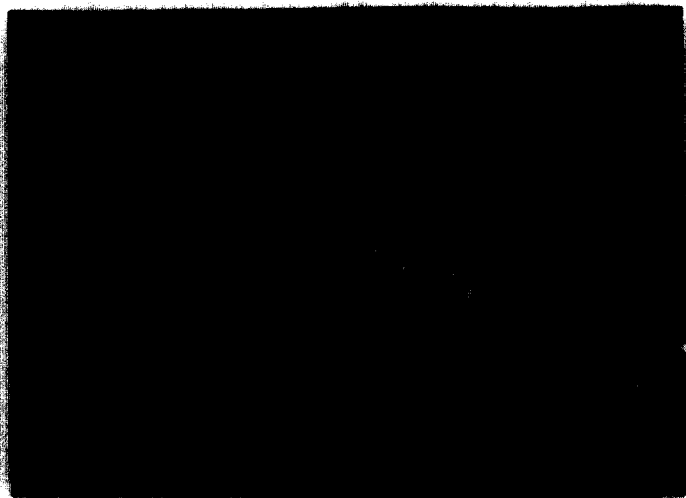


FIGURE 1.—Aeration basins at Spring Grove, Pa.

ultimate necessity for a higher degree of treatment, aeration needs to be supplemented. Shortly a turbo-aerator will be installed in each of the two basins to provide additional oxygenation over that provided by the pumping and riffing. A similar installation is planned for another mill employing a turnover rate of 10 times daily, together with turbo-aerators in each basin (17).

Another means of supplemental aeration is under investigation at the Cantonment, Florida, mill of the St. Regis Paper Co. Here a riffle run 1,000-ft (305-m) long and 100-ft (30.5-m) wide was constructed using 7 low dams, the areas between which are filled with rubble in order to create turbulent flow. Up to the present this

small unit has received a daily flowage of from 30 to 35 mgd (113,700 to 132,650 cu m/day) and produces a BOD reduction of about 15 percent. Tests are under way now to determine its efficiency at lower through-put rates and with the addition of nutrients. Influence of passage through the riffle run on subsequent storage oxidation will also be explored.

An intensive investigation of high degree mechanical surface aeration was conducted at the P. H. Glatfelter Co. mill at Spring Grove, Pennsylvania, and is reported by Weston and Rice (16). A view of the aeration basins employed is shown in Figure 1.

Six entrainment aerators, three per basin, of 60 hp (61 hp metric) each were employed in the trials. BOD re-

TABLE II.—Effect of Aeration Treated Effluent on Storage Oxidation

Ratio Treated (Eff.: Raw Waste)	Storage Period (days)	BOD (mg/l)					
		Raw Waste	Treated Effluent	Mixture	Removed		
					Treatment	Lagoon	Total
Waste Alone	20	210	—	81	—	129	129
1:3	3	213	18	90	49	74	123
1:2	5	173	8	59	55	59	114

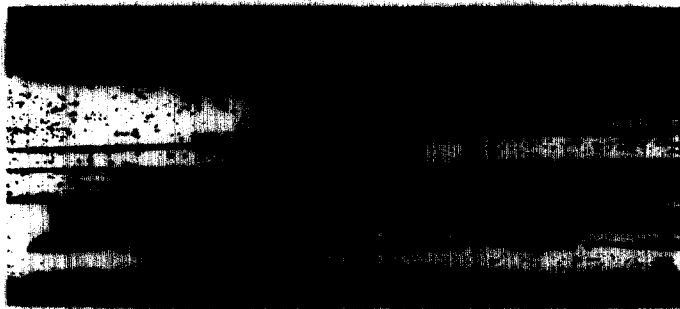


FIGURE 2.—Raft-mounted surface aerator.

duction for two basins having a combined detention period of four days varied from 62 to 82 percent during the summer and fall months.

Another means which has been tried, on a pilot-plant scale, for increasing the efficiency of stabilization basins treating kraft pulp mill effluent, is by pretreating a portion of the clarified effluent by the activated sludge process and combining it with the remainder for stabilization treatment. Table II indicates that storage for three days of 1:2 and 1:3 mixtures of treated and raw effluents produced a final effluent as good or better than that observed for 20-day storage of the raw waste alone. It is believed that a combination of preconditioning and seeding

is responsible for the increased activity in the basin. A similar observation has been made for a basin following a plastic media trickling filter treating kraft mill effluent.

Basin Circulation

Employment of aeration and aerating devices for basin circulation is also receiving attention. Diffused air delivered through drilled pipe has been employed in some instances but raft-mounted mechanical entrainment aerators appear to be a more practical approach. One such raft-mounted device installed in a basin at Georgia Pacific Paper Co.'s Oregon mill, is shown in Figure 2.

Data on the effectiveness of partial

TABLE III.—Performance of Aerated and Recycled Stabilization Basins

Type of Waste	Basin Depth* (ft)	Detention (days)	Air† (cu ft./gal)	Recirc. (%)	Temp. (°C)	BOD			
						(mg./l)			Reduction (%)
						Inf.	Em.	Removed	
Flax Pulp	6	1	0.75	20	13-16	73	40	33	45
Int. Kraft ↓	10	4	1.35	0	20-36	252	89	163	64
	10	4	1.93	0	26-39	213	40	173	81
	10	3	1.80	0	26-40	193	52	141	73
News Chip ↓	5	9	0	16×	Winter	533	240	293	55
	5	9	0	16×	Spring	542	208	334	62
	5	9	0	16×	Summer	515	110	405	78
	4 to 5	10	1.00	0	87-64	378	122	256	68

* Multiply by 0.3 to obtain meters.

† Multiply by 0.008 to obtain cu m/l.

TABLE IV.—Performance of Stabilization Ponds in Reducing BOD

Mill Product	Type of Treatment System	Pond Area* (acres)	Max. Retention (days)	BOD		
				Influent (mg./l.)	Effluent (mg./l.)	Removal (%)
Newsprint	Multiple plus Flowage	100	20	200	40	80
Bleached Kraft	Single	215	30	290	157	48
Newsprint	Single	140	15	180	110	39
Unbleached Kraft	Multiple plus Flowage	350	82	200	20	90
Bleached Kraft	Single	175	35	108	36	67
	Single plus Flowage	4,480	180	130	10	92
	Single	300	40	150	45	70

* Divide by 2.47 to obtain hectare.

aeration and mixing of stabilization basins is presented in Table III. The high BOD reductions obtained during relatively short storage periods demonstrate the effectiveness of this practice. There is no question that the BOD loading rate can be greatly increased; however, the relationship between the degree of mixing and aeration to the increase in efficiency under similar conditions remains to be determined.

The most extensive system of this type combines long withholding of mill effluent together with stabilization. This installation, located at the Springhill, Louisiana, mill of International Paper Co., has been described by Coogan (18). Covering over 5,000 acres (2,020 hectare), these basins are capable of withholding the entire effluent from a 1,500 ton/day (1,360 metric tons/day) bleached kraft mill for a period of as long as 14 mo for discharge over the month or two of high runoff that occurs in the receiving watershed annually. Facilities are also provided here to fill the basins with fresh water during the same period for use in the mill throughout the year. As a basin is emptied of fresh water it is used to receive effluent.

Design Requirements

Stabilization basins will probably always be designed on the basis of the land available of suitable topography. However, from what has been learned,

ideal design requirements can be set forth. These are as follows:

1. Stabilization basins must receive ~~waste free of settleable solids~~. For this purpose, large circular clarifiers are used. However, it is well to provide a small basin between the pond and the clarifier which will allow solids passing the clarifier during periods of upset or repair to settle prior to entering the oxidation basins. This basin should be so arranged that it can be bypassed for cleaning.
2. Basins are best built in multiple and operated in series to prevent short-circuiting. At least two separate basins should be used or a dividing wall provided if a single basin is employed.
3. All dykes should be built properly with a knowledge of soil conditions and core walled where stability is questionable.
4. Basins should be cleared of stumps and the bottom compacted when this treatment is indicated. Porous areas should be filled with dispersed clay.
5. Inlet and outlet structures should be designed to provide for changing the water level for mosquito control.
6. If basin depth exceeds 3 ft (0.9 m), air or mechanical mixing should be provided if high BOD reduction is to be achieved in a relatively short storage period (10 days). Design for unmixed basins providing a

ent (%)	Removal (%)
80	
48	
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67	
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high degree of BOD reduction is based on a loading of 1.2 lb/day/1,000 sq ft (0.13 g/day/sq m), 1.7 to 2.3 lb/day/1,000 sq ft (0.2 to 0.3 g/day/sq m) for agitated basins.

7. Intensively aerated basins having very short storage periods (four days or less) offer no appreciable advantage over the activated sludge process either from the standpoint of capital or operating cost, and are not capable of providing as good a quality of effluent, particularly in respect to suspended solids content.

Conclusion

Stabilization basins are rapidly gaining recognition as an established treatment process and are not to be confused with uncontrolled storage basins which do not compare with them in performance and have, in many instances, earned an unsavory reputation. How effective the process can be is illustrated by the data presented in Table IV. We are, at present, witnessing the development of smaller basins of higher performance and a bright future can be predicted for them.

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